Design of Backpacking Tent Accessories through the Lens of Wilderness Medicine

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A special thank you to
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Introduction












In the world of outdoor recreational equipment, few items are as ubiquitous as the tent. Tents commonly manifest themselves everywhere from family campgrounds to the high peaks of the Himalayas. While these products differ in many ways due to their specifically intended uses, at their core they are very similar. The role of any tent is to serve as a temporary, portable shelter from the elements and because of this, the vast majority of tents are typically designed around a certain key collection of specifications focused solely on performance. Backpacking tents – the focus of this project – are designed with the intention that they will be carried by a user while hiking or trekking for an extended period of time. The key metrics for backpacking tents include low weight, a high space to weight ratio, sturdy construction, and reliable protection from inclement weather while features like doors, vents, well-sized vestibules (a sort of “garage” for your tent), and ease of setup are also important design considerations that can make the tent a successful product. For tent manufacturing companies to be competitive in the market, they have to continually best their competition in the key technical categories while also providing unique feature offerings. Due to these constraints, the changes seen in the marketplace are often very incremental and rarely create a substantial impact on the current state of the art. Weight, size and weather-resistance are important design factors, but they are far from the only concerns of avid hikers and backpackers.

Wilderness medicine is a practice that focuses on medical incidents such as the cuts, stings, sprains, and bruises can happen at any time when participating in outdoor recreation. While these medical events would often be minor concerns in day-to-day life, they can quickly escalate to very serious situations when out in the wilderness, hence the need for a unique field of medicine. These potential complications are due to the remote nature of these trips – meaning injuries stay untreated longer - and the increased presence of bacteria and viruses, especially when





dealing with a cut or laceration. Often times in the wilderness, these medical situations need to be dealt with in a very improvised manner and few pieces of gear are designed specifically for this, meaning that any available supplies or equipment may need to be repurposed. Furthermore, there is a good chance that if a wilderness medical situation occurs, that the individual will have reduced physical abilities in some way, shape, or form.

With this knowledge in hand, a thought experiment was devised: what can be learned about tents and tent usage if examined from a non-traditional perspective, such as that of wilderness medicine? Wilderness medicine provides a very interesting and complex “lens” to examine tents through because most of the time it addresses worst-case scenarios – the outliers. Similar to Universal Design, if designs are focused more on these outlying medical situations – things that can result in reduced mobility, strength, and awareness, to name a few – then it follows that accommodation could be improved for all other users. More so, the possibility even exists that the tent, or aspects of the tent, could actually play an active role in addressing wilderness medical scenarios. The goal of this project is just that, to first examine tents and all of the intangibles associated with them through this “lens” of wilderness medicine. Once completed, the second phase is to examine the information gathered and apply this knowledge to the creation of new products or components related to current tent technology. The ideal outcome is a new tent whose refinements and innovations improve a tent’s usability in a wide variety of situations.










Tents

Camping and hiking have long been part of the fabric of our human experience. One may be wont to say that camping and hiking developed about the same time that hominids learned to walk on two legs. However, it is largely held that camping and hiking, as a recreational activity, began over 100 years ago, largely because of the efforts of a man named Thomas Hiram Holding and his boyhood experiences while crossing a large portion of the United States in a wagon train. Holding published the Camper's Handbook in 1908 and since then, the popularity of this recreational activity has only continued to grow. The Outdoor Foundation, a notable nonprofit established by the Outdoor Industry Association to "inspire and grow future generations of outdoor enthusiasts" compiles yearly reports on national outdoor recreational trends. According to their research, 8.35 million people participated in overnight backpacking in 2010, a notable 9.3% increase over the previous year – especially in the midst of a recession (Outdoor Foundation, 2011).

Tents, too, have a long lineage, being mentioned in the first book of the Bible, Genesis. Historical manifestations of the portable shelters have been used everywhere from the armies of the Roman Empire to the Plains Indians of North America, where they were called teepees. The modern, familiar form of the camping tent began to take shape in the late 1960s and early 1970s, when there was a huge surge in the popularity of recreational hiking and camping. Today, there are hundreds of varieties of tents and an average of almost 9 million tents are sold on a yearly basis (Outdoor Industry Association, 2011).

Single Wall Tent. This tent is made of a single layer of breathable waterproof fabric.

Double Wall Tent. This tent has an inner, breathable layer (grey) and an outer, waterproof layer (green).

There are many varieties of tents in current use, but for the purpose of this project, the focus will be on those utilized for backpacking and hiking. Tents come in two main configurations: single wall and double wall. Single wall tents are made of a single layer of breathable waterproof fabric that is suspended over a pole structure. A double wall tent, as its name implies, is comprised of two layers with only the outer layer being waterproof. Double wall tents are generally durable, cheap, warm, heavy/bulky (compared to single wall), and moderately hard to pitch while single wall tents are less durable, more expensive, and colder, though they are lighter and easier to put up. Double walls tents are the best choice for most users because of their price and flexibility. However, this is not to say that a single wall is not the right tent for certain uses, especially where weight is the driving factor

Tents also come in two main shape profiles, though many minor variations exist. These profiles are largely dictated by tent pole arrangement. Dome tents are freestanding structures that are generally shaped like a dome and rely on crossing poles to create a rigid frame while the other variety of tent is the tunnel tent, which is formed by multiple parallel hoops formed by the poles. These tents require guy lines to keep them upright.

Dome tent

Tunnel tent

On a double wall tent, the interior layer, referred to as the inner tent, is often constructed of a breathable, water permeable fabric suspended by a pole structure with a form factor that is often similar or identical to that of a single wall tent. The primary difference in this type of tent is the addition of a waterproof rain cover called a flysheet, rain fly, or fly for short. The fly extends all of the way to the ground, providing protection from the elements. Rain flies also have the benefit of often being oversized so that they create a covered storage area, called a vestibule, for any gear that a user may not want to bring inside of the tent itself, but still want to be protected.

Double wall tent with fly pulled back

Double wall tent with fly removed

Double wall tent with fly open, revealing vestibule area

The poles that make up these varying tent structures are typically constructed from thin, flexible tubes of aluminum, fiberglass, or even carbon fiber. Today's standard poles are comprised of multiple pieces of these thin sections that are all linked by an elastic cord. These sections are packed in a collapsed state for transport, but have ends that fit into one another to form a full unit. These poles are then either inserted into sleeves on the inner tent and then used to erect the inner tent or are first constructed into a frame so that the inner tent can be connected to it using small hooked pole clips. Two other types of structural members for tents do exist, but are less widely accepted and thereby less commonly used than the standard poles. One utilizes a hiker's trekking poles to create a simple, support structure, while the other replaces poles with a technology known as "airbeams," which are fabric tubes that can be inflated to provide a rigid structure almost identical to that formed by the flexible poles.

Collapsed tent poles

Tent pole clip close-up

Tent pole sleeve close-up

Tent using airbeam technology

Tent using a trekking pole as primary support

The last primary tent component is the tent stake. These small, yet important items can be made from a variety of metals or plastic and serve as anchors for the tent. Tent stakes are crucial for tying out the guy lines (support lines) of tunnel tents, as mentioned above, but are also required to keep freestanding tents from shifting or blowing away in a wind. Tent stakes range from simple, nail-like pegs to complex extruded sections meant to provide high amounts of ground gripping force.

Tent stake in use

Tents provide many options outside of these primary components too. Air vents are prevalent to reduce condensation and interior organizers are helpful to stow gear. Furthermore, tents range widely in size and weight. Often backpacking tents (tents made to carry long distances) are not made for more than four people because of weight considerations, but it is easy to find 1-, 2-, 3- and 4-person versions. For the purpose of this project, the focus will be on 2-person, double walled dome tents, as these are one of, if not the most popular variety of backpacking tent.

Wilderness Medicine

Wilderness medicine is the name given to the practice of medicine in remote and austere environments including both first aid and, if necessary, secondary care. Wilderness medicine is a relatively new and unique field that is specially tailored to deal with the “unique challenges and emergencies that arise in diverse environmental conditions far from definitive medical care” (Stanford School of Medicine, 2012). One of the main defining factors of wilderness medicine is that, more often than not, the tools and equipment for properly dealing with a medical situation are not available when needed. Consequently, the fundamental key to wilderness medicine is a careful amalgamation of improvisation and hard medical science. Creativity and ingenuity are immeasurably important in the wilderness, where one must utilize whatever supplies or materials that are available and depend heavily on common sense medical knowledge (Weiss, 2005).

Utilizing whatever materials are on hand is a key identifying factor of wilderness medicine. Often times in a wilderness medical situation, first responders are instructed to repurpose natural items, such as sticks, or even common gear items to aid a fellow backpacker. Backpacks can be disassembled to utilize their various straps; t-shirts become padding, tourniquets, and slings; sleeping pads become leg splints, and so on. The reasoning for not bringing dedicated medical equipment is because, in reality, the rate of critical injuries is very low. The National Outdoor Leadership School (NOLS), along with Outward Bound, are the leading outdoor leadership education programs in the United States – having trained over 120,000 individuals in courses ranging from two weeks to two semesters. As a top program, NOLS is very conscious of risk management and gathers substantial amounts of data on the topic – especially in backcountry settings. NOLS’s research has shown that their injury rate for backpacking is only 0.77 over almost 200,000 program days. Therefore, it is not at all pragmatic to carry the extra

weight necessary for medical equipment. However, this 'cannibalization' of gear can result in gear being permanently ruined or at least unusable until the patient is safely in professional care - which can potentially pose other problems - even if those are as simple as "how do I carry all of this now that my backpack is being used as a rescue tool?"

As the practice of wilderness medicine matures, so does the understanding of the most common injuries and illnesses, their prevalence, and their causation. Being armed with this important information better enables individuals to take preventative measures to mitigate potential situations and to make the necessary pre-trip preparations to handle situations if they do arise.

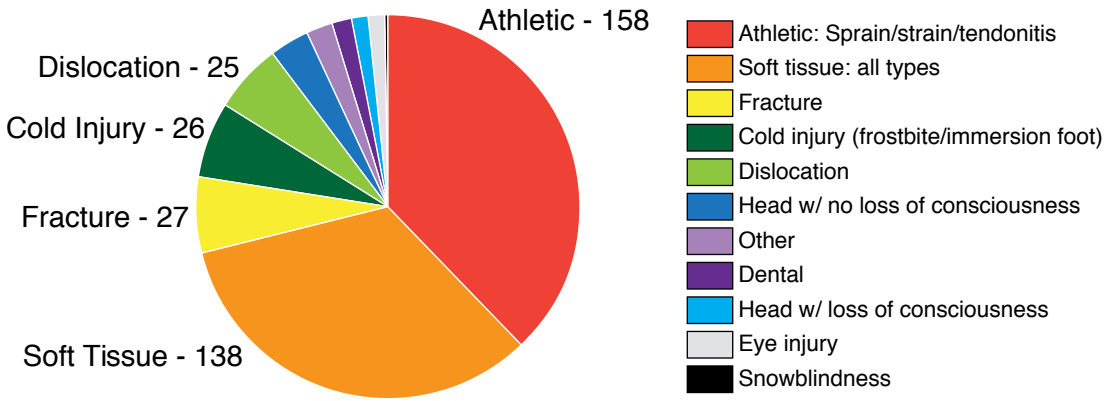
The following tables and charts consist of voluntarily submitted incident data to NOLS over a 9-year span (1998-2007). The data shows that athletic injuries (strains/sprains/tendonitis) and soft tissue injuries (bruises/contusions/wounds) are overwhelmingly the most common incidents recorded and more often than not these injuries concern the knees, ankles, and lower back (Leemon, 2007), a finding that has been corroborated by numerous other sources (Hamonko, McIntosh, Schimelpfenig, & Leemon, 2011; Lobb, 2004; McIntosh, Leemon, Visitacion, Schimelpfenig, & Fosnocht, 2007; Twombly & Schussman, 1995).

Injury Rate per 1000 Program Days - Backcountry Only
1998-2007: Participants and Staff
Backcountry Program Days: 801,569

Type of Injury	# Injury	Injury Rate	Evac	Evac Rate
Athletic (Strain/Sprain/Tendonitis)	158	0.20	103	0.13
Soft Tissue: All Types	138	0.17	63	0.08
Fracture	27	0.03	21	0.03
Cold Injury (Frostbite/Immersion Foot)	26	0.03	16	0.02
Dislocation	25	0.03	13	0.02
Total Backcountry	**416**	**0.52**	**239**	**0.30**

(Leemon, 2007)

Types of Backcountry Injuries



Profile of Injuries by Activity with Injury Rates - Backcountry Only
with injuries and injury rates per 1000 program days
**Injury rates calculated by activity specific exposure (program days)*
1998-2007: Participants and Staff

Activity	# of Injuries	Program Days	Injury Rate
Backpacking	145	188,970	0.77
Camping (incl. cooking)	42	196,270	0.21
Winter Camping	5	1,289	3.88
All Backcountry	**416**	**801,569**	**0.52**

(Leemon, 2007)

AN OPPORTUNITY EXISTS TO DESIGN THROUGH THE LENS OF WILDERNESS MEDICINE AND CREATE A PRODUCT THAT IS CONSIDERABLY MORE INTUITIVE, RELIABLE, AND HELPFUL THAN OTHERS ON THE MARKET

Methods

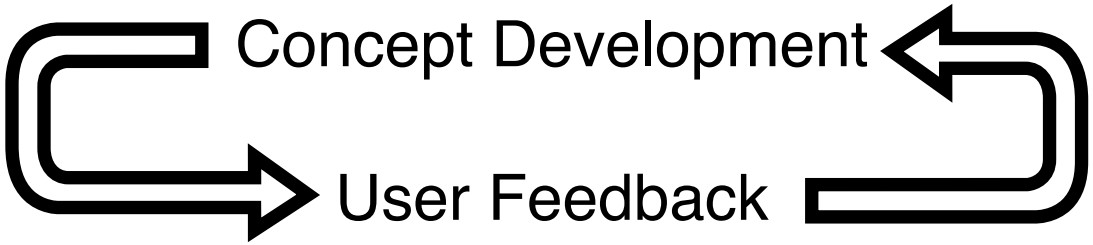
Survey

Pilot User Study

User Study

Decide Final Design Direction

Ideation

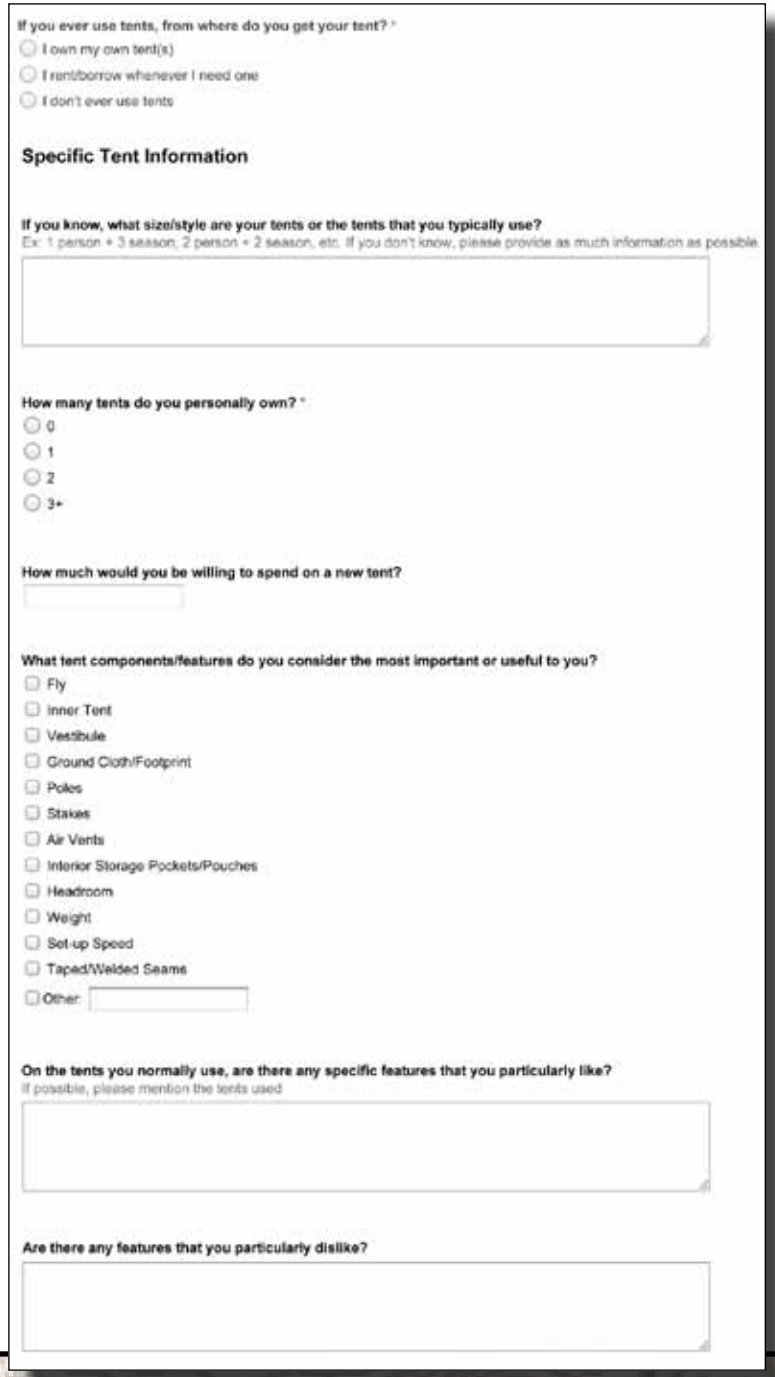


Final Product

Survey

This short survey was used to aid in identifying aspects of tents that warrant further exploration and focus. A number of short answer questions were included to get a deeper understanding of potential areas for improvement regarding tents.

Interviews with wilderness medical professionals were also conducted early on and were utilized to gain further insight into wilderness medical practices and, most importantly, these professionals' personal experiences that may not have been available in published literature.



If you ever use tents, from where do you get your tent? *
- I own my own tent(s)
- I rent/borrow whenever I need one
- I don't ever use tents

Specific Tent Information

If you know, what size/style are your tents or the tents that you typically use?
Ex: 1 person + 3 season, 2 person + 2 season, etc. If you don't know, please provide as much information as possible.

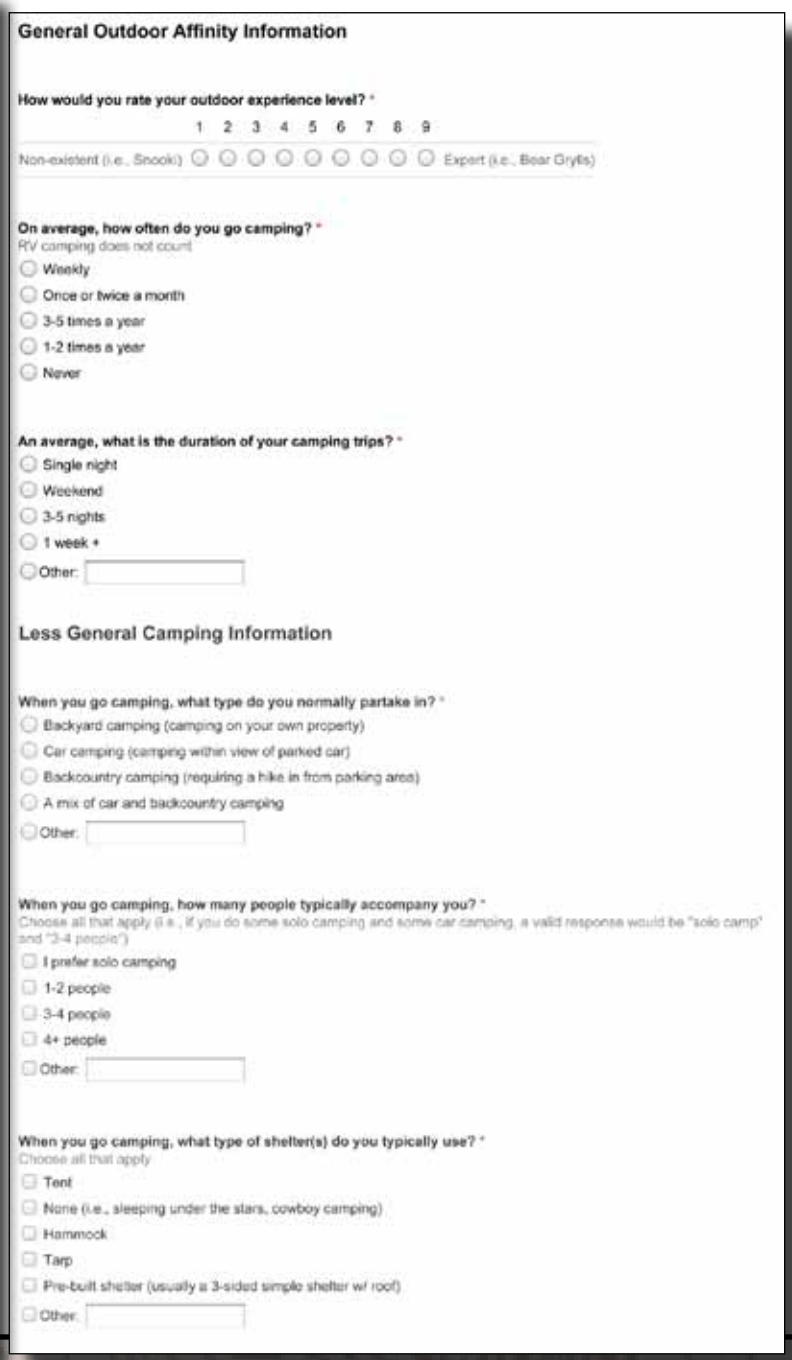
How many tents do you personally own? *
- 0
- 1
- 2
- 3+

How much would you be willing to spend on a new tent?

What tent components/features do you consider the most important or useful to you?
- Fly
- Inner Tent
- Vestibule
- Ground Cloth/Footprint
- Poles
- Stakes
- Air Vents
- Interior Storage Pockets/Pouches
- Headroom
- Weight
- Set-up Speed
- Taped/Welded Seams
- Other:

On the tents you normally use, are there any specific features that you particularly like?
If possible, please mention the tents used

Are there any features that you particularly dislike?



General Outdoor Affinity Information

How would you rate your outdoor experience level? *
1 2 3 4 5 6 7 8 9
Non-existent (i.e., Snooki) ○ ○ ○ ○ ○ ○ ○ ○ ○ Expert (i.e., Bear Grylls)

On average, how often do you go camping? *
RV camping does not count
- Weekly
- Once or twice a month
- 3-5 times a year
- 1-2 times a year
- Never

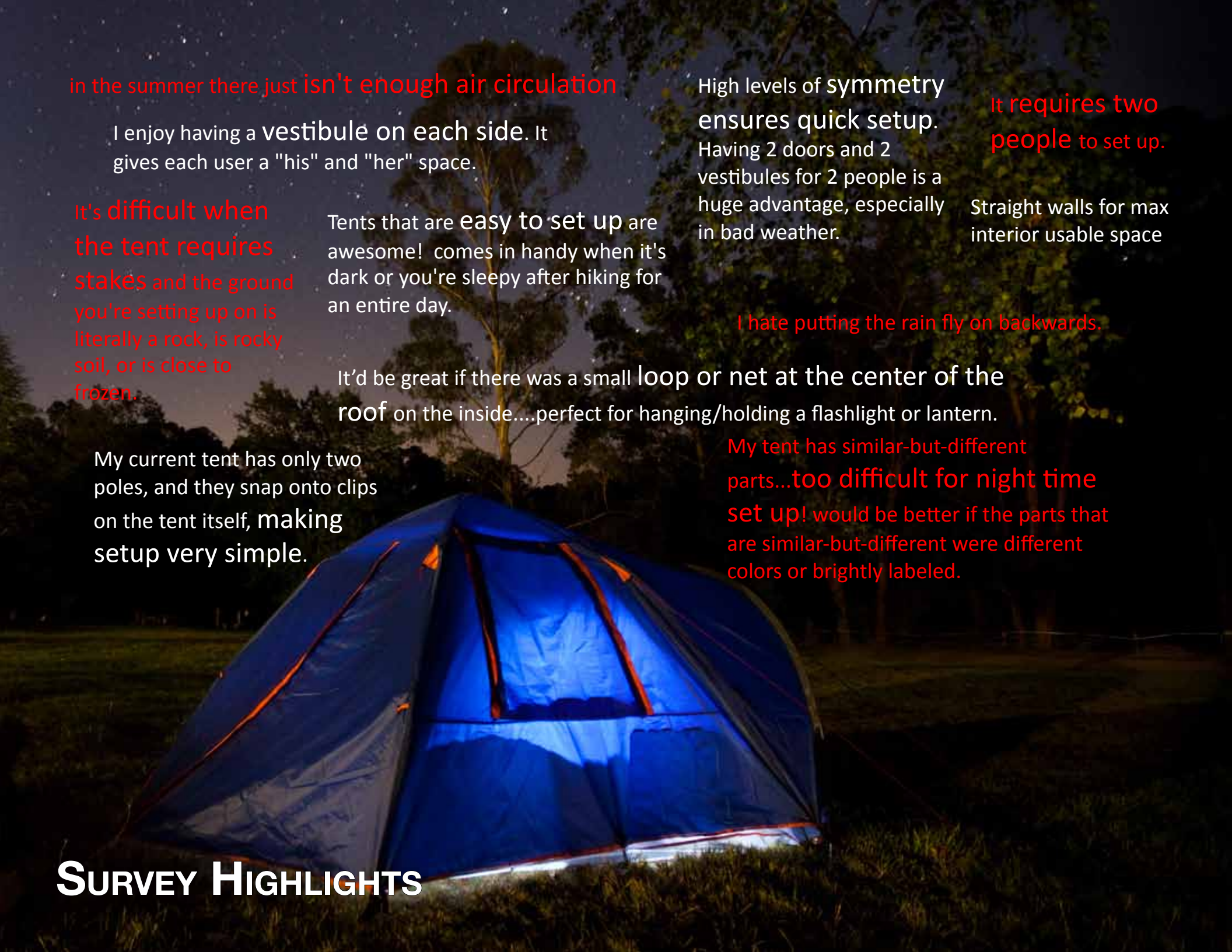
An average, what is the duration of your camping trips? *
- Single night
- Weekend
- 3-5 nights
- 1 week +
- Other:

Less General Camping Information

When you go camping, what type do you normally partake in? *
- Backyard camping (camping on your own property)
- Car camping (camping within view of parked car)
- Backcountry camping (requiring a hike in from parking area)
- A mix of car and backcountry camping
- Other:

When you go camping, how many people typically accompany you? *
Choose all that apply (i.e., if you do some solo camping and some car camping, a valid response would be "solo camp" and "3-4 people")
- I prefer solo camping
- 1-2 people
- 3-4 people
- 4+ people
- Other:

When you go camping, what type of shelter(s) do you typically use? *
Choose all that apply
- Tent
- None (i.e., sleeping under the stars, cowboy camping)
- Hammock
- Tarp
- Pre-built shelter (usually a 3-sided simple shelter w/ roof)
- Other:



Survey Highlights

in the summer there just isn't enough air circulation

I enjoy having a vestibule on each side. It gives each user a "his" and "her" space.

It's difficult when the tent requires stakes and the ground you're setting up on is literally a rock, is rocky soil, or is close to frozen.

Tents that are easy to set up are awesome! comes in handy when it's dark or you're sleepy after hiking for an entire day.

High levels of symmetry ensures quick setup. Having 2 doors and 2 vestibules for 2 people is a huge advantage, especially in bad weather.

It requires two people to set up.

Straight walls for max interior usable space

I hate putting the rain fly on backwards.

It'd be great if there was a small loop or net at the center of the roof on the inside....perfect for hanging/holding a flashlight or lantern.

My current tent has only two poles, and they snap onto clips on the tent itself, making setup very simple.

My tent has similar-but-different parts...too difficult for night time set up! would be better if the parts that are similar-but-different were different colors or brightly labeled.

Pilot User Study

An preliminary round of user testing was performed to solidify how to go about the tent testing process. The chosen method of user testing was to place each user in a potential wilderness medical scenario and have them interact with a tent. This interaction included setup, utilizing each of the tents' features, entering and exiting the tent, and packing the tent up. The pilot user study helped to vet each wilderness medical scenario that could potentially be used, and to determine necessary time frames and procedures for the actual users. Initial reactions to interacting with two tents were also recorded while performing the pilot study to provide a better focus for the final user tests and for gaining a better understanding of the usability problems that may arise due to these scenarios.

Tent	Scenario	Setup Time (min)	Breakdown Time (min)	Notes
Eureka Aurora 1	Right arm in sling	11	8	Reduce initial setup force. Add tensioners for poles.
	Left leg in brace + socks on hands	11.5	7	Increase grip on key setup areas.
Kelty Streamside 2 AL	Right arm in sling	10	7	A tough design with limited limbs.
	Left leg in brace + socks on hands	9	7	Clips are desirable w/ limited friction + dexterity.

User Study

The purpose of the user research was two-fold:
1. To gain insight into the ways in which wilderness medical situations may effect user interaction with a 2-person backpacking tent.
2. To identify the key problem areas and areas for potential improvement in regards to tent features

"Wilderness Medical Tent Scenario"
For this user research, ten subjects with at least a basic level of experience with tents and backpacking were recruited and were placed in one of three simulated wilderness medical scenarios (injured leg, injured arm, frostbite). This required the investigator to fit the subjects with either a leg splint (around the knee), an arm sling, or GTRI's Arthritis Simulation Gloves (a legitimate analog for frostbitten fingers in gloves). The subjects were then asked to complete a entire cycle of tent usage (from the tent being packed away in its storage bag to fully setup and then back to a packed state) with one of three 2-person tents. During this process, subjects were video recorded for post-study analysis and were asked to think out loud and vocalizes any thoughts, observations, or reactions to the exercise to better expose potential areas for improvement. Following the exercise, the subjects were debriefed in a group with the investigator to cover any further thoughts or insights that may not have come up during the study.

Frostbitten Fingers

Injured Knee

Injured Arm

Initial Findings

Poles

Problems:

- Pole sleeves are annoying and tough to use with one hand
- Using a combination of sleeves and clips is not very intuitive
- Many new pole configurations pack poorly
- With less common pole configurations, user made educated guesses on pole direction and orientation
- Grommets are tough to insert pole tips into and remove - though they stay in place well
- Standard pole clips are difficult one-handed

User Suggested Improvements:

- Intentionally twisted pole clips really improve usability

Rain Fly

Problems:

- Getting the fly oriented correctly is often a matter of educated guesswork
- Grommet attachment for the fly is difficult and requires unstaking each corner
- Fly is tough to connect and there is often no manner of applying extra force (i.e. a thumb loop)
- Side release buckles are tough to connect with one hand

User Suggested Improvements:

- Make the connection points color coded

Stakes

Problems:

- The stakes are somewhat tough to use, but not any more than usual
- Its hard to put in the stakes if one's bending is impeded (ex. leg injury)

User Suggested Improvements:

- When its tough to do, you can use some types of stakes to remove other stakes

General Set Up

Problems:

- The tent keeps trying to move when inserting poles (single person set up)
- If the tent is not symmetrical, the set up orientation matters, especially on an incline
- Too much confusion in setting up the tent results in other key steps being forgotten
- Instructions are helpful, but I'm not going to carry them more then once, even if I forget how to set up the tent

User Suggested Improvements

- Staking the tent out before connecting the poles helps immensely
- The tent should not be directional unless absolutely necessary

Packing

Problems:

- Utilizing the stuff sacks is difficult, especially with one hand or gloves.
- Rolling the tent works well, but only if rolled tightly enough to fit into the stuff sacks

User Suggested Improvements:

- Use an oversized stuff bag

Ingress/Egress:

Problems:

- Because of their height, tents require individuals to crawl in and out of them, which is especially tough with an injury of any sort

Miscellaneous

Problems:

- Zippers are hard to grab and use, particularly when the pull is too short
- It is very easy to lose the extra stowage bags, especially if it is windy
- Spring loaded toggles and slide locks are tough with one hand

Identification of Latent Needs

After the initial video transcription, a second analysis of the videos was completed with much more of a focus on the users' actions and unvoiced issues. What quickly became apparent was that none of the participants in the study were able to fully insert the stakes into the tough, gravel-laden ground that the testing took place on. Staking a tent is critical for one person set up and even more critical for ensuring that the shelter stays put in the chance of inclement weather or wind gusts.

Numerous examples of tent stakes that are poorly placed in the ground

Initial Design Metrics

1. Incorporate basic Wilderness First Aid components into the final product (sling, splint)

2. Accessory bags and other small components should be tough to lose

3. Tent stake placement and removal is often difficult and requires undue pressure on hands and/or feet. Make the insertion and removal process less taxing on users.

4. Decrease the physical difficulty associated with re-stuffing the tent into its bag

5. Tent pole configuration should be straight-forward and symmetric to avoid improper placement

6. Remove any confusion surrounding fly orientation

7. Affordances should be made where ever force needs to be applied on a regular basis (especially zipper pulls and near the corners of the fly and inner tent)

8. Reduce the force needed to connect the tent poles to the inner tent's corners

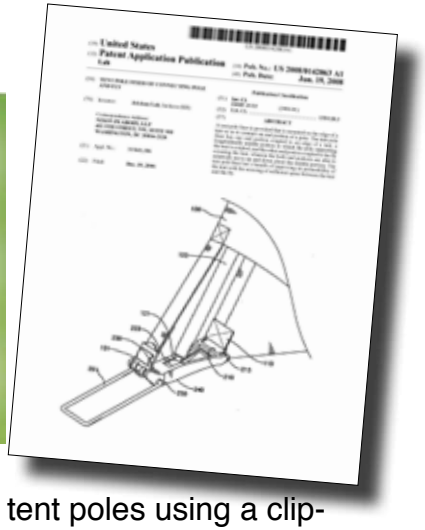
9. It should be possible to connect and remove the fly with one gloved hand

10. Reduce the need to crawl in and out of a tent by increasing the door and vestibule clearance

Accessories **Inner Tent** **Fly** **Poles**

Prior Art and Patent Search

One of the biggest findings of the post-user study patent searches was the Jake's Foot, made by the Dongah Aluminum Corporation (DAC), who are often considered the industry standard for tent pole technology. The Jake's Foot, patented under the name of Tent Pole Fixer, is a small plastic component being used predominantly by Sierra Designs and by Nemo on some of their tents, including a number of award winning tents.



The Jake's Foot securely holds the end of the tent poles using a clip-in ball joint connection. This removes the need for having to deal with difficult grommets and provides a good grasping point for applying extra tensional force on the corners of the tent if needed. The Jake's foot also removes the need for buckles or extra grommets to attach the fly to the inner tent, which caused trouble for the users that I tested. Instead, the fly connects straight to the Jake's Foot using a small hook that is quite easy to use one-handed. Furthermore, the Jakes Foot ensures a more repeatable fly to inner tent spacing that allows for increased air flow. Removing the components from the Jake's foot is straight forward too: just twist the fly hook to remove; twist the Jake's foot and the pole will pop right out as well. All in all, the Jake's Foot effectively solves Design Metrics 7-9 in a very elegant fashion.

Another DAC product that seemed to cure a lot of usability issues is their Twist Clip, which was found on one of the tents used in the user study. The standard tent pole clip has simply been given a small twist along the length of its body that the users really responded to. It was even quite usable while wearing the arthritis simulation gloves

A final critical issue was the need for a better tent opening to ease ingress and egress (Design Metric 10). While many tents are lacking in this area, that is not to say that all tents are. One excellent example is the Hilleberg Allak 2-person tent (shown below), which has an incredibly large door opening and an asymmetric fly construction to allow users to easily get in a out of the tent and also provides for high amounts of airflow in nicer weather.

Design Process

Due to the findings of the patent and literature searches, it was concluded that a full redesign of a tent was unnecessary as there were less usage issues associated with the tent than originally hypothesized. This is likely due to the fact that tents, as discussed, are a product that has already been through many years of refinement. Furthermore many thoughtful designs do exist that ease the process of setting up and using the tent. However, no tent could be found that incorporated all of these useful components.

Some small scale testing *was* completed to determine proper sizing of areas of the tent and to make sure that these innovative components worked as advertised. Then, a design recommendation checklist was produced as a tool for tent designers in lieu of a new tent. However, as this is not the primary focus of the project, it has been included as an appendix.

THE USER RESEARCH AND PRIOR ART SEARCH IDENTIFIED THE UNDERLYING ISSUES WITH TENT SET-UP AND SHOWED THAT THE BIGGEST DESIGN OPPORTUNITY WAS NOT WITH THE TENT ITSELF, BUT RATHER WITH THE ITEMS SURROUNDING IT

Refined Design Criteria

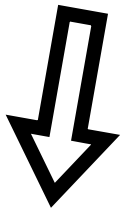
1. Incorporate Wilderness Medical tools or components that address the most common backcountry injuries into the final design.

2. Design accessory bags and other small components in such a way that there is no way that they can be lost.

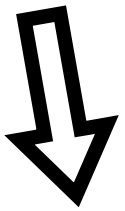
3. Reduce the usability issues faced surrounding tent stake usage and develop a product or method to aid in proper tent stake placement and removal using either hands or feet.

4. Decrease the physical difficulty associated with removing and re-stuffing the tent into its bag.

7. Affordances should be made to enable easier use of zipper pulls anywhere on the tent.



Design a product or method to ensure 1) proper placement and 2) user-friendly tent staking



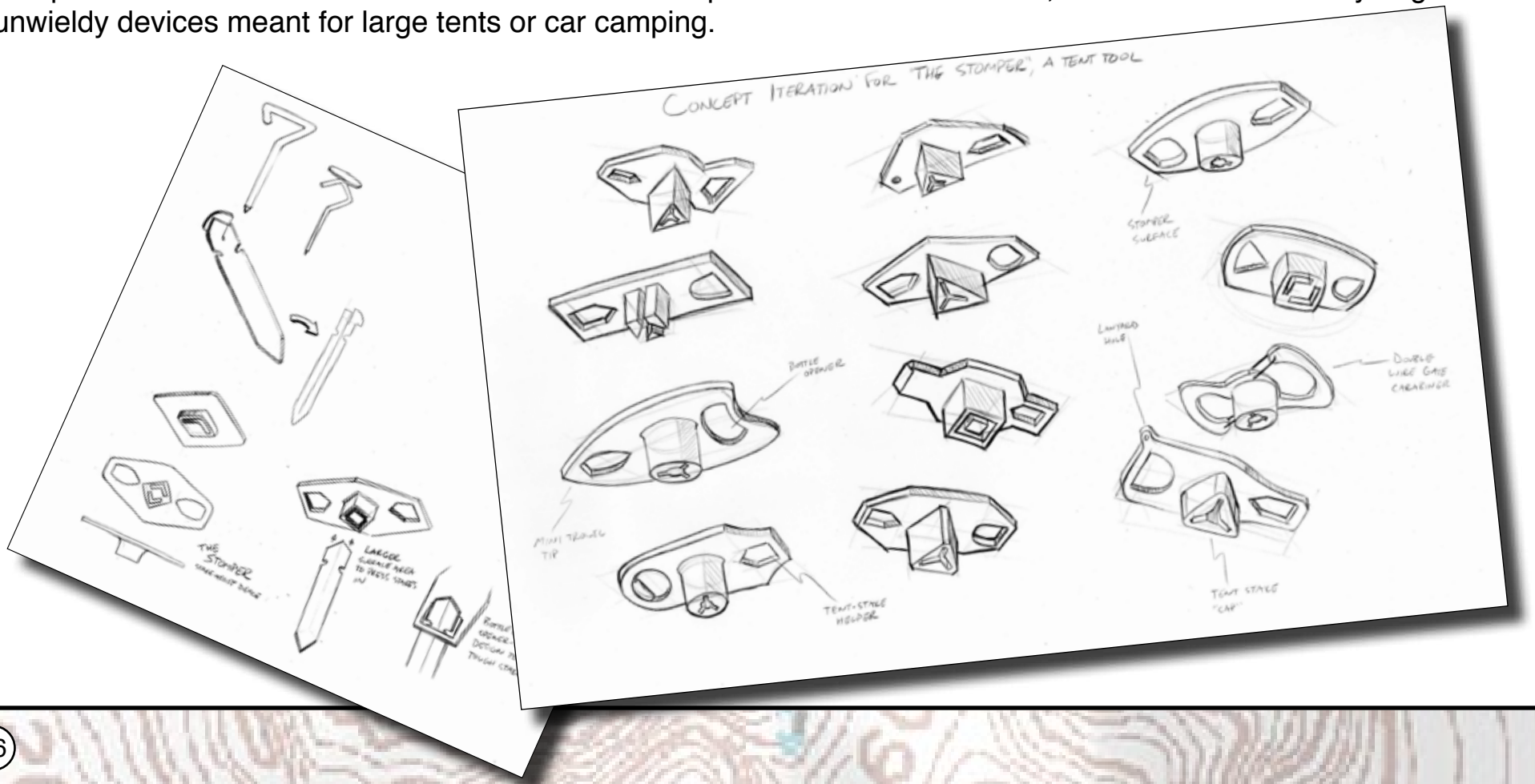
Develop a tent storage bag that has 1) improved usability considerations and 2) that can provide injury support

THE FIRST CHALLENGE TO TACKLE WAS IMPROVING THE ENTIRE PROCESS OF TENT STAKE USE

Tent Stake Tool Concept

The tent stake tool began as an exercise in redesigning the tent stake itself. Tent stakes are obviously one of the most crucial aspects of tent usage, however, they are typically designed from a purely engineering perspective - meaning that function is paramount. Because of this, their usability suffers immensely, and that was a fact that was all too apparent in the user testing.

During initial ideation, changing the stake itself began to make less and less sense. Changing the design of tent stake itself would result in added costs and bulk that would then be multiplied for each stake carried by the user. Altering each and every stake is unnecessary if there was just some device that make stake usage easier. Product and patent searches revealed a few number of “stake pullers” and stake mallets, but these were all fairly large and unwieldy devices meant for large tents or car camping.



Tool Concept Development

A collection of the key revisions in the tent tool design process

The first iteration of the tent tool actually seemed as if it would work surprisingly well, though it certainly needed a good deal of refinement and further development to take it from a cardboard model to the final product.

The tool was originally intended to solely push stakes into the ground and then remove them, but it also provided an interesting potential solution for the problems that were experienced trying to use zipper pulls that were too small. Adding a zipper-pull aiding mechanism would give the tool a necessary secondary function after the stakes had been placed.

Tool User Tests

After three prototypes had been created in different sizes and shapes, another small user test was necessary.

Backpackers were enlisted to put in tent stakes using any method that they were currently used to using. After observing them placing and removing stakes, they were then handed the tool with no information regarding how it was to be used. Immediately, all of the users started using it in exactly the intended fashion and were able to place each stake more quickly and deeper into the ground than the control test. This was the case with both hand and foot usage - meaning that this tool was already successfully addressing one design criteria.

All were impressed with how well it worked and, while they provided a number of design recommendations, the consensus was that the tent tool was an incredibly helpful piece of gear.



One user first tried to use her foot to press the stake in, but it kept falling over. She then resorted to using a rock to pound it in, which is a very common backpacking practice that is even suggested in many “how-to” guides for tent stakes. However, she proceeded to injure a finger, thereby causing an unnecessary wilderness medical situation.

Placing stakes with two hands

Pushing a stake in with a foot

Another individual utilizing a rock as a hammer

The insertion and removal process of stakes using the tool







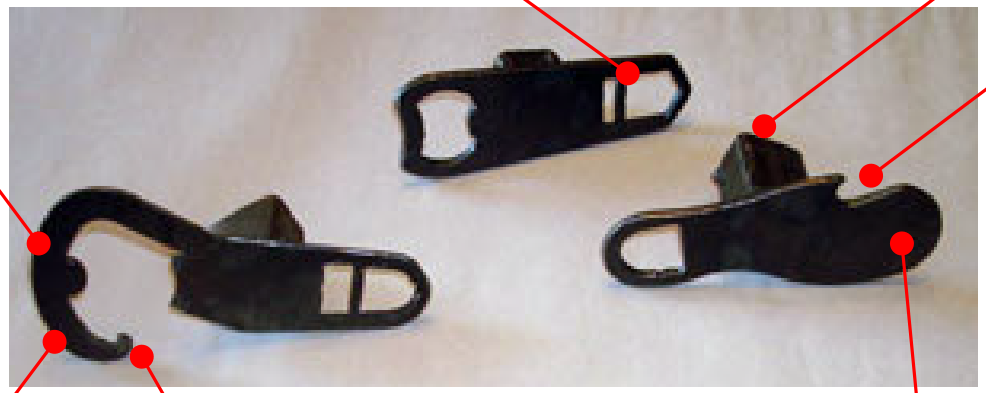

Further Refinement

After the user testing, there were a number of things that needed further refinement. The final size and shape of the stake pushing section was undecided, a target weight needed to be set, and the size of the individual tools needed to be finalized. It was finally decided that the stake pushing section should be a simple cylinder to accommodate the two most common types of extruded tent stakes (V and Y cross section stakes) and should be 0.75” long to minimize deflection when using the tool. Talks with a number of backpackers and camping enthusiasts solidified the target weight at <2 ounces,

The size of the carabiner is great for two fingers to grab and pull, but the bump in the middle hurts

The secondary stake pulling hole (grabs the “hooked” area of the stake meant to hold the guy lines) is useless when its this small

The pushing device can be used as a grasping point to help pull out the stakes, but it needs to be a more ergonomic shape



No need for an in-line bottle opener with all that extra space

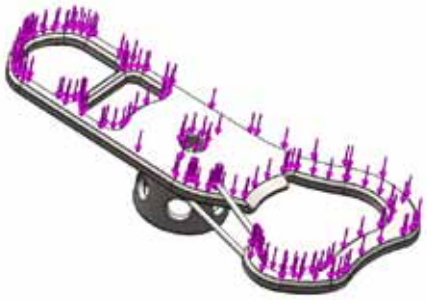
While its well sized for fingers, its a little too big for a pocket tool

The carabiner can be used as the zipper helping tool

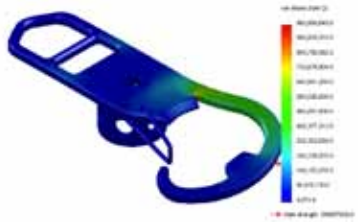
The novelty boot shape is cute, but unnecessary. There is way too much unused material. That will really increase the weight

Materials Analysis

Once the design was nearly finalized, a material analysis was completed using SolidWorks' built-in Finite Element Analysis tools. For this analysis, the tool was simulated as being fixed on its center point, as if it were in the process of pushing a tent stake into the ground. Then, a constant 180 pound force was applied to the top surface of the tool, as if a large male individual were placing most his weight on to the tool - a realistic usage scenario. This resulted in two key design changes. Firstly, extra material was able to be removed from the model - especially in the carabiner region - to further reduce the tool's overall weight. Secondly, it was determined that 7075 aluminum could be a legitimate material option for this tool, which drops the overall weight to about half of an ounce.

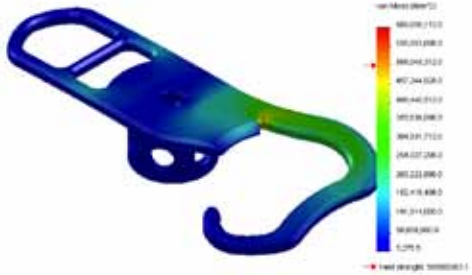


180 Pound Applied Force

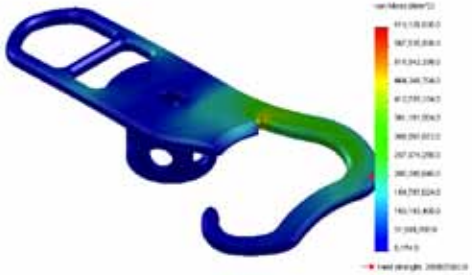


Originally analyzed tool form

7075-T6 Aluminum



Principal Stress



Principal Stress

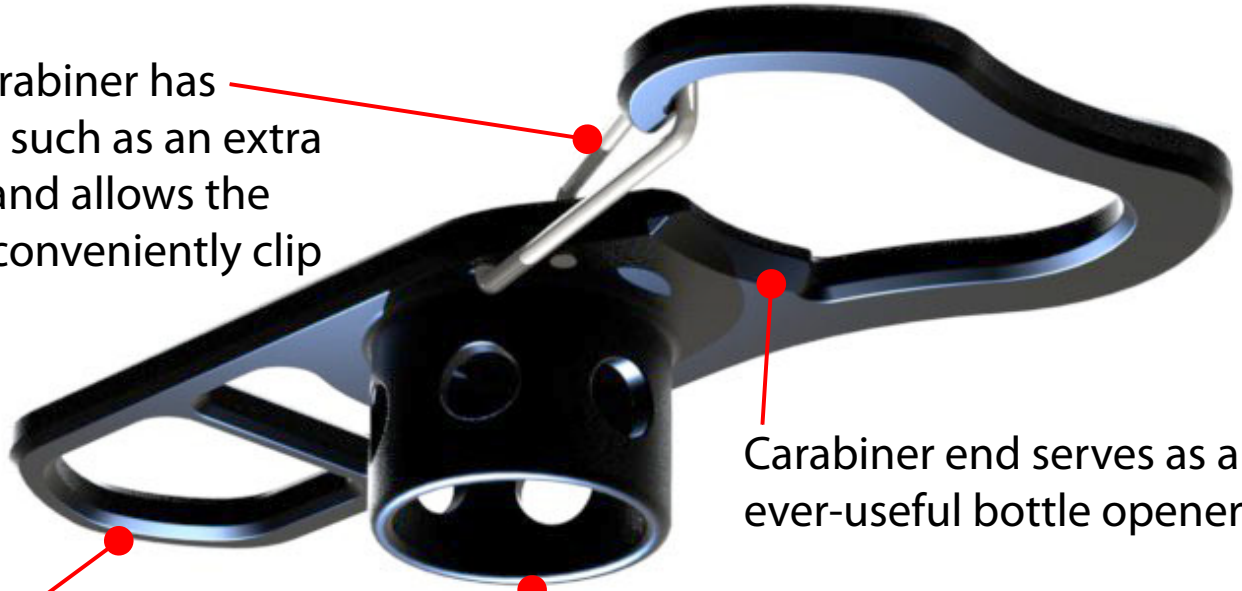
Displacement

Displacement

304 Stainless Steel

The Stake Stomper

Wire gate carabiner has myriad uses, such as an extra zipper pull, and allows the Stomper to conveniently clip to your gear



Carabiner end serves as an ever-useful bottle opener

Tent stake pulling tool provides leverage for pulling even the toughest stakes out of the ground

Tent stake "cap" for pushing Y- and V-profile stakes into any type of ground

Why permanently cannibalize gear in an emergency situation when it can, instead, be designed precisely for this multi-purpose use?

Tent Bag Design Goals

Tents normally come in very simple stuff sacks (though some companies are branching out) that include a main bag and two smaller accessory bags for the stakes and the poles. The first goal of the tent bag redesign was to get rid of this paradigm and create a single bag that housed all three items. This change would also aid in simplifying how the bag was used. Different people use different methods of packing their tents and this bag should reflect this dichotomy. Therefore, another key goal of this tent bag redesign was to create a bag that was conducive for use with either rolling or stuffing a tent.

Finally, because wilderness medicine is a huge concern - it was important that wilderness medical tools were worked into the design. Hikers and backpackers, when placed in an emergency situation, are known for being resourceful and using whatever is around them. It is paramount in these rare, but critical, emergency situations that everyone involved think clearly, not panic, and problem solve a solution. But, what if one of these steps was already taken care of? If the necessary tools are available in a usable form, like a standard emergency care provider, then that is simply one less stressful component to focus on.

However, backpackers are also notorious for minimizing their gear, so an entire first aid kit is out of the question. However, if these tools are integrated into a common piece of gear it would warrant quicker adoption, a higher likelihood of usage, and therefore a better handled situation should an emergency ever arise. Furthermore, if designed correctly, no piece of gear would have to be permanently sacrificed - saving a costly replacement.

1. Incorporate wilderness medical aids/supplies
 - Ankle support
 - Arm sling
 - Arm/leg splint

2. Design for easy packing whether the tent is rolled or stuffed

3. Mitigate the potential of misplacing the tent and pole bags

4. Compress tent for smaller space claim when packed

Standard tent and accessory bags

The original “slim” sling/tent pole bag. It measured 4” from top to bottom and barely covered the forearm.

The initial idea for the tent bag/sling combo. It was simply mocked up with fabric, safety pins, and masking tape. The concept was a Velcro closure bag.

The first sewn prototype of the tent bag. It incorporated all of the components that were mocked up with masking tape, as well as including the ankle wrap that doubled as a sling strap

The first step to designing the tent bag was to be certain that there was a way to integrate the sling into the bag in some way. Initially, the idea was to make the tent pole bag in such a way that it could convert into a very slim sling. However, upon reexamining common tent bag sizes, it was found that standard medical slings do not considerably differ in size from them. Most slings are around 6 inches from top to bottom and from 16-18” long. Tent bags range from 5-7” in diameter (16-19” circumference, or 8-9.5” inches from top to bottom) and from 17-23” long. Therefore, with some minor adjustments, the bag itself could easily work as the sling.

A secondary realization, from examining ankle support products, was that the typical ACE bandage design, if modified, could easily act as not only an ankle wrap, but also as the shoulder strap for the sling. Having an item that could serve two uses would definitely cut back on weight on the complexity of the system.

Incorporation of Bag, Sling, and Ankle Wrap

Early prototype tent bag in use as an arm sling

The shoulder strap of the sling successfully doubling as an ankle wrap

Development of Compression Methods

It was important that the sling strap/ankle wrap be incorporated into the tent bag as an integral component, rather than just tacked on. This feature's form lent itself to acting as a compression strap, therefore numerous methods were tried to incorporate it in this manner.

Thread thru loops and double back
*Final selected method

Figure 8 Wrap

Spiral Wrap

Laced Closure

Loop and Eyelet

Doubled-back Velcro

Design Evolution

Square shaped bag with a sleeve for the tent poles and a Velcro flap to secure it shut

Resized square shaped bag with a sleeve for the tent poles and stakes. Closure uses Velcro straps double backed through D-rings.

Square shaped bag that incorporates an interior mesh pocket. This pocket makes the opposite side of the bag act as more of a flap, but gets in the way of the sling usage.

Cylindrical bag with a dual-zip front flat and a fixed back. Bag partially closes using a Velcro mesh panel, and uses an hook and eyelet-like closure mechanism.

The final prototype was another cylindrical bag. The Velcro was still used to secure the mesh section, though this was to be replaced with a zipper in the final bag. The new compression wrap method using the ankle wrap/sling strap was also implemented.

B.O.W.A.

Big Orange Wilderness Aid

A wilderness medical support tent storage bag

Main Features

Final Tent Bag Features

Specifications:

- Silnylon and nylon webbing
- 5.5 ounces
- Packed size is 20” x 6” diameter

Wilderness Medical Features:

- Converts into sling
- Compression strap acts as an ankle wrap and sling strap
- Bag can also be used as a knee, ankle, or arm splint
- Mini interior front pocket is perfect for holding first aid supplies
- Bright orange color and reflective appliqués are helpful for signaling

General Features:

- Two packing options:
- Open flat for a roll-up bag
- Keep zipped for an oversized stuff sack
- Can be used as a tent storage bag when uncompressed – mesh allows tent to breathe
- Tent bag can be hung inside of tent to be used as a gear loft
- Integrated tent pole and stake pockets mean no misplacing small bags
- Water resistant
- Acts as a shoulder bag for mini trips around the campsite

Detail view of first aid supply pocket

Bag in use as a sling

Reflective strips on bag

While backpackers are known for being resourceful in unexpected situations, why should they be expected to solve yet another problem while a fellow backpacker is in need of medical treatment?

Use as a bag

Bag can be carried via the compression strap

Undo compression strap by releasing Velcro and removing strap from D-rings

Empty contents of bag by opening all zippers and removing all components

The bag is now empty and able to be used for another purpose

If a rolled tent is preferred, roll the tend and place on the flat bag

Zipper the central mesh section and the two ends

Fasten the central compression strap by doubling back through the D-ring

Finish packing by fastening the larger two compression straps by doubling back through D-rings

Use as an Arm Sling


Lay bag on ground and begin removing compression strap by unthreading through the reflective webbing


With compression strap removed, connect the orange-bordered slotted end to the black quick connector


Lace the opposite end of the strap through the D-rings at the front of the tent bag and attach the strap to itself using the Velcro tab


Adjust as needed and place patients arm in sling.

Use as an Ankle Wrap

Ankle wrap use requires removing the compression strap from the bag as shown in the sling diagram

Start wrapping at ball or arch of foot, continuing under foot from inside to outside.

Make 2 or 3 turns around foot moving towards ankle with each turn overlapping one-half of the previous layer.

Begin a figure-eight turn bringing bandage up outside of foot, over instep and inside around ankle.

Continue down inside of foot around heel, back up over instep, down under foot, and back up completely around ankle.

Repeat the figure-eight 2 or 3 times overlapping one-half of the previous layer and rising above the ankle.

Secure above ankle with Velcro tab

Use as a Leg Splint

Lay the bag flat on the ground under the patient's affected limb

Make sure to place tent poles or other straight, rigid objects in the tent pole sleeve to act as the splint

Attach the central strap, making sure that it is not over a joint. It is a good idea to place padding in a splint for comfort

Wrap the lower compression strap around the patient's limb, making sure it is snug, but not cutting off circulation

Repeat this process for the upper compression strap

The sling is now ready for use.

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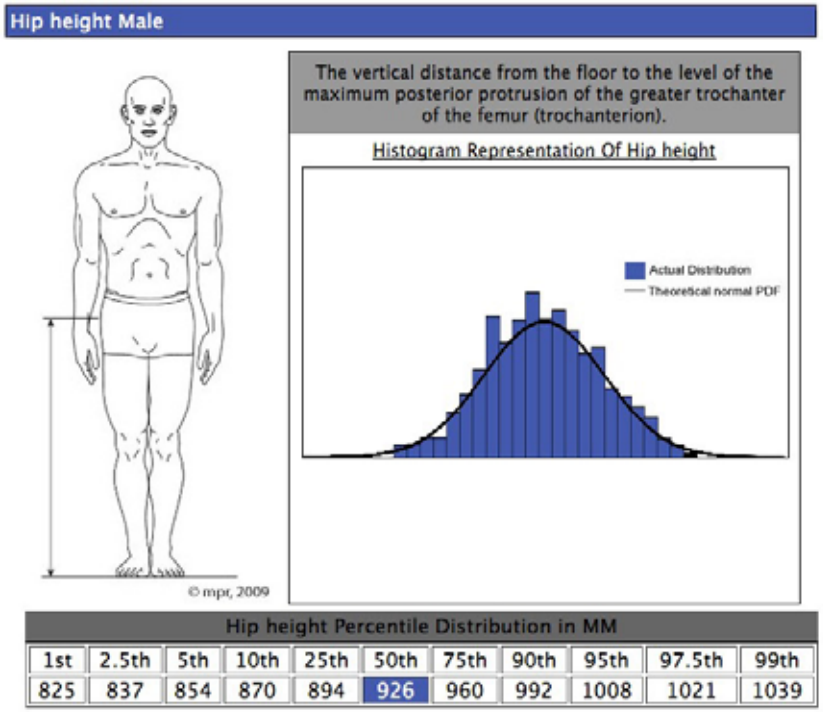
APPENDIX

Tent Ingress/Egress Testing

Tent ingress and egress (getting in and out of the tent) was noted as a key issue in all of the tents that were tested. Because of the importance of easily getting into one's shelter, especially in a potentially wilderness medical situation, tent door sizes were a primary concern. Though tents were found that solved this problem well, experimenting with door sizing was still a definite priority to provide adequate design recommendations.

A rig was constructed that was exactly half of the size of a standard two person tent. This allowed for the door panel to be rigged and tested without needing to sew an entire tent. A few different door shapes were tested that were sized in accordance with the 95th percentile hip height dimensions in the ANSUR database (a 1988 anthropometric study on military personnel). This dimension ensured that the bottom opening of the door was at least 40" (1008mm) which should allow for a large segment of the population to easily swing their legs into the opening from a seated position in the tent rather than crawl.



Hip height Percentile Distribution in MM

1st	2.5th	5th	10th	25th	50th	75th	90th	95th	97.5th	99th
825	837	854	870	894	926	960	992	1008	1021	1039

The testing rig

Offset fly

Fly open, revealing door

Open door, with storage space under fly visible

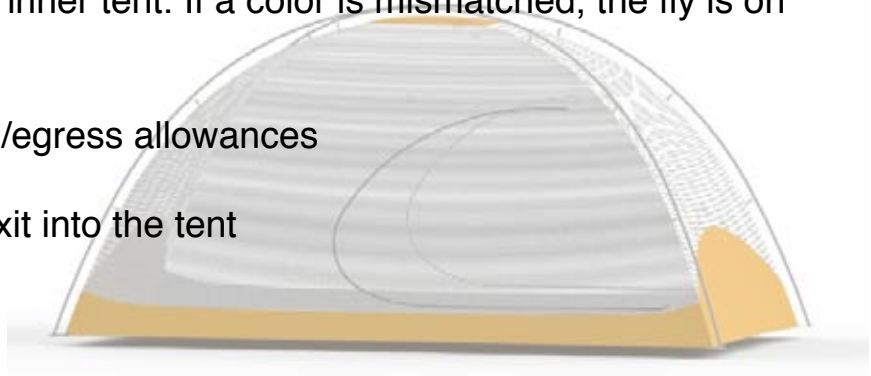








Proposed Tent Design Guidelines



Color coded webbing on the corners where the fly attaches to the inner tent. If a color is mismatched, the fly is on incorrectly.

Doors must be at least 40” in their bottom edge for proper ingress/egress allowances

An offset/asymmetrical fly construction can also ease entry and exit into the tent

Utilize Jake’s feet corner connections to ease pole connection

Utilize pole clips (unless sleeves are absolutely necessary), especially the Twist Clips

Use a symmetrical inner tent shape to ease set up and tent orientation

Use a simple, symmetrical pole construction if possible, that way the poles can be set up in any direction on the inner tent and it will not be wrong

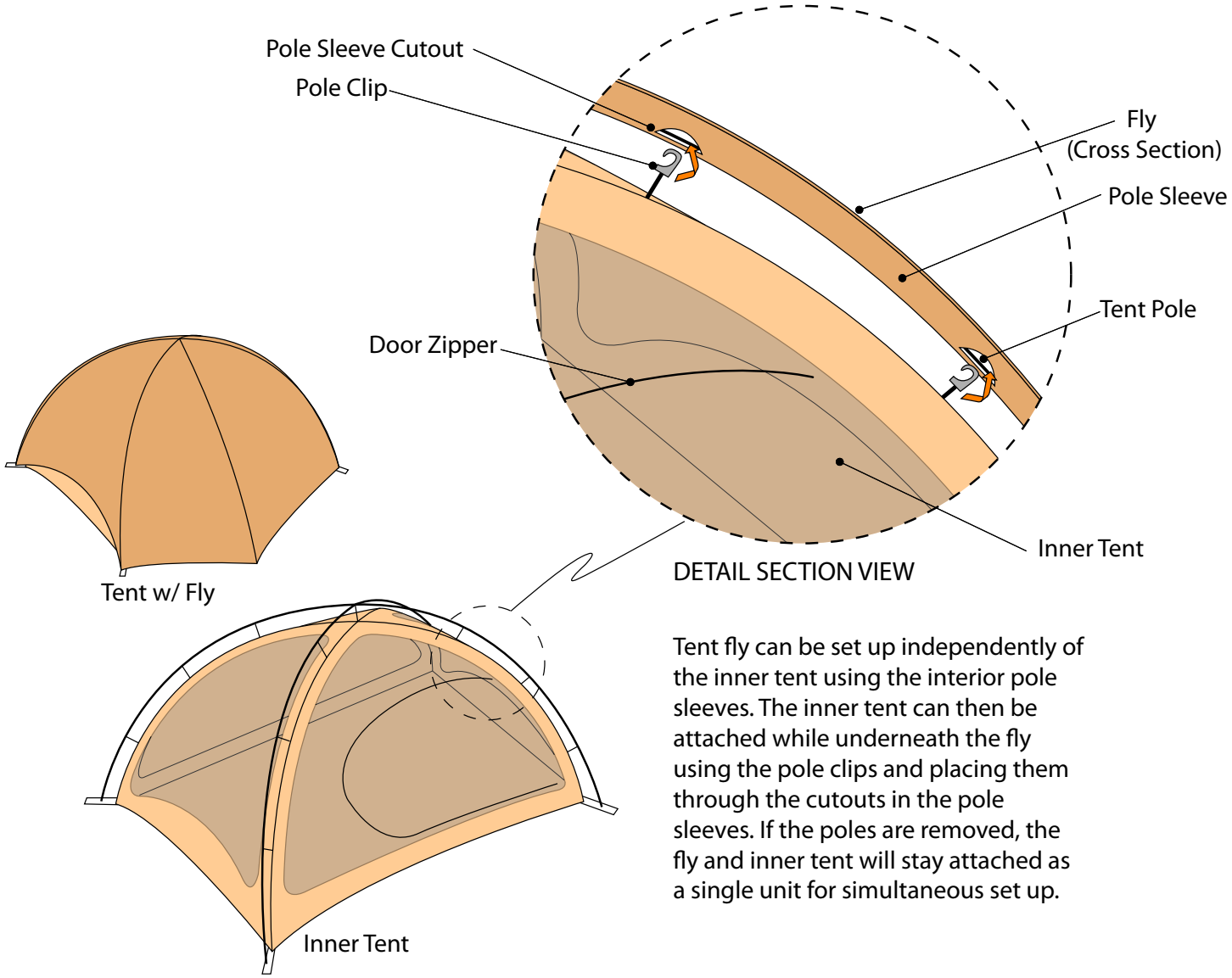
Incorporate large thumb loops made of webbing wherever there are not already affordances for extra tensional force. The Jake’s feet have affordances for this in the form of the tent stake loop, but there is no reason that a thumb loop can not be applied here as well, and on the fly-to-Jake’s foot connection as well

Add printing or patterning to the fly to ensure that the right side always faces out.

Utilize some type of fly-to-inner tent connection method that allows for the two to be pitched simultaneously in inclement weather. See image for a proposed example.

Proposed Tent Changes

A proposed method of attaching the inner tent to the outer tent, thereby easing setup, especially in inclement weather



Tent fly can be set up independently of the inner tent using the interior pole sleeves. The inner tent can then be attached while underneath the fly using the pole clips and placing them through the cutouts in the pole sleeves. If the poles are removed, the fly and inner tent will stay attached as a single unit for simultaneous set up.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